IMPACTS OF CLIMATE CHANGE ON RESIDENTIAL ELECTRICTY CONSUMPTION: EVIDENCE FROM BILLING DATA

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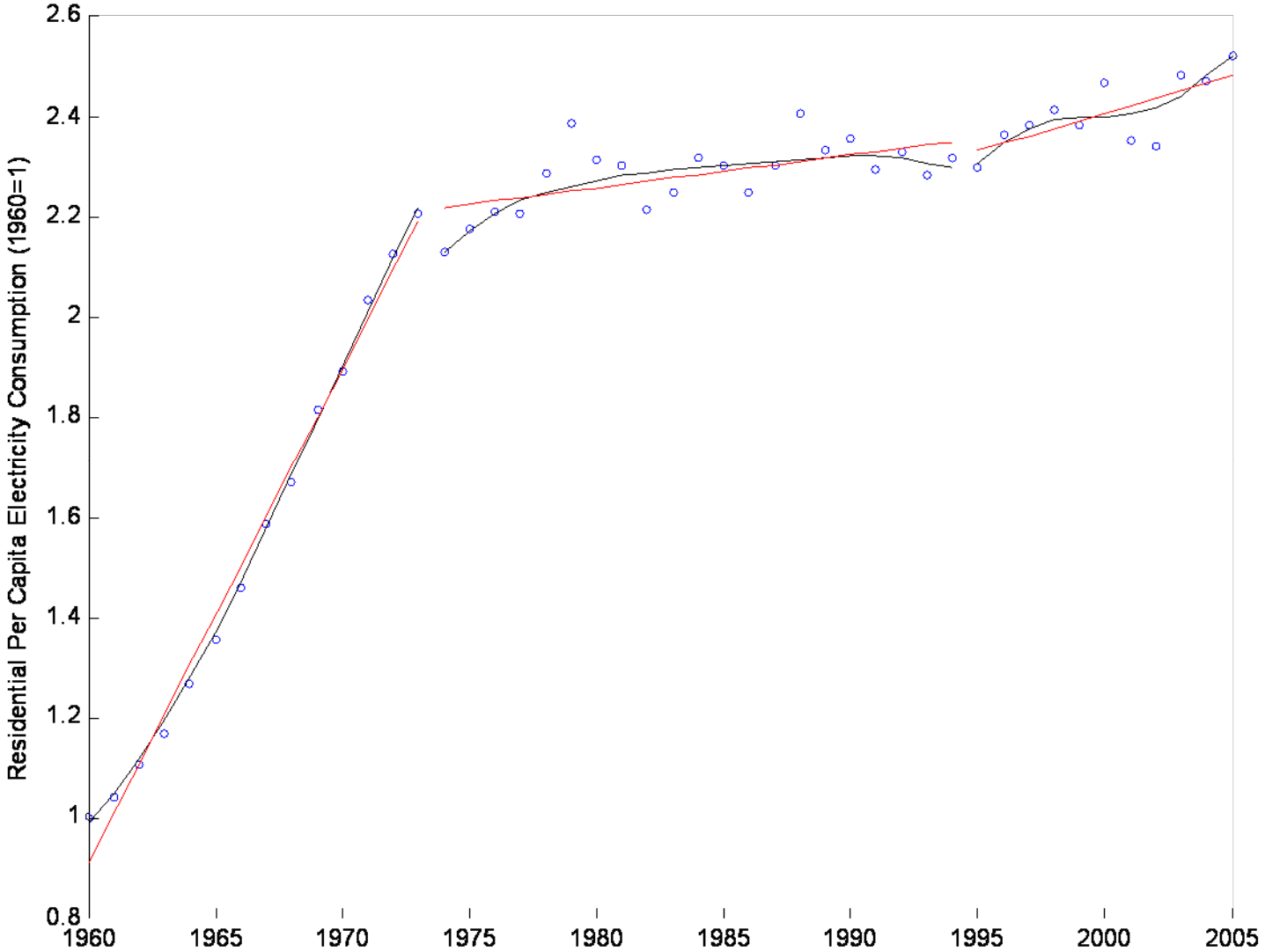
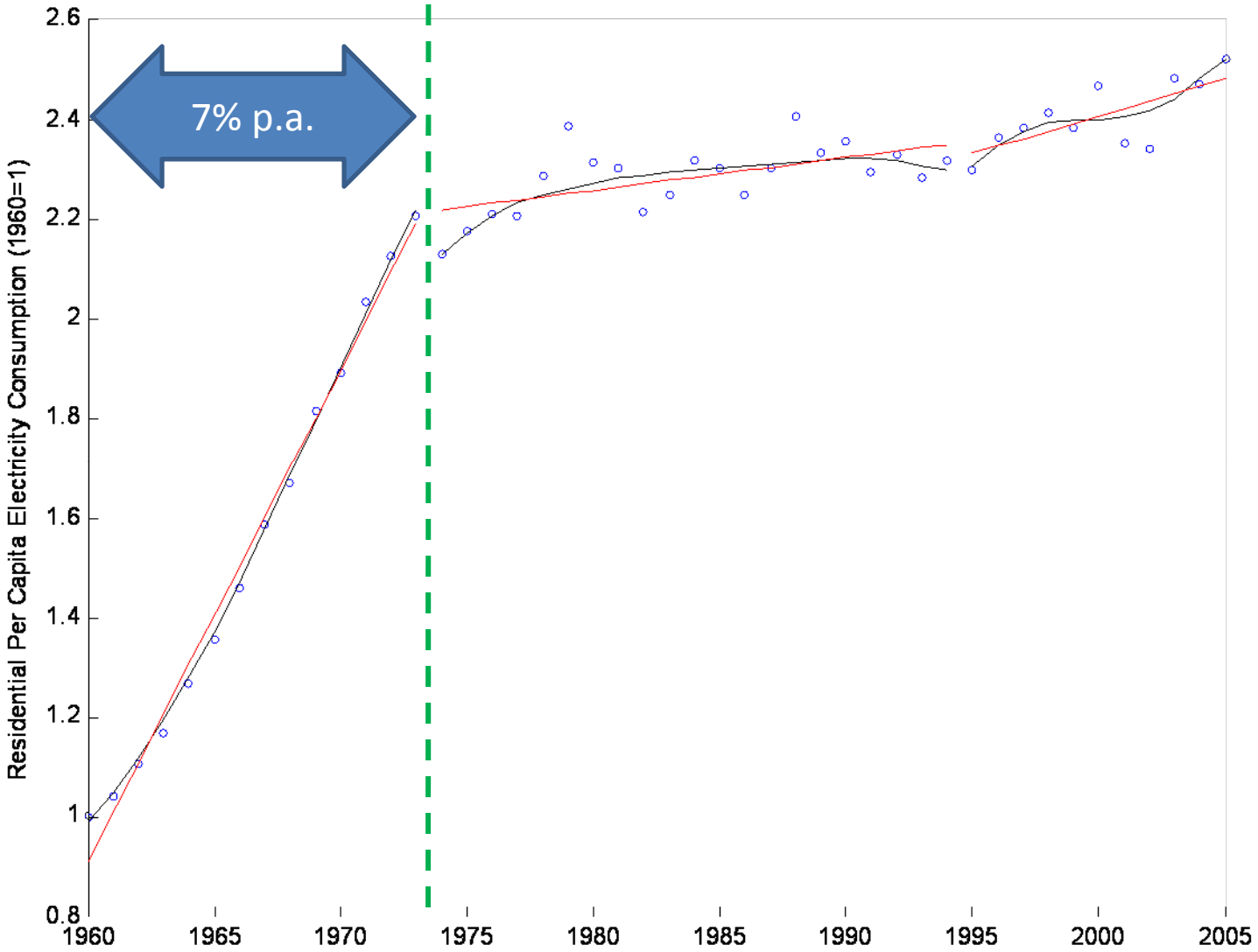
California's Residential Sector Electricity Consumption

- More than quadrupled since 1960
- Share in total consumption increased from 26% to 34%.
- Consumption equivalent to total consumption of Finland, Argentina or half of Mexico
- Provided by three major investor owned utilities (SCE, SDG&E, PG&E) and over 100 municipal utilities.

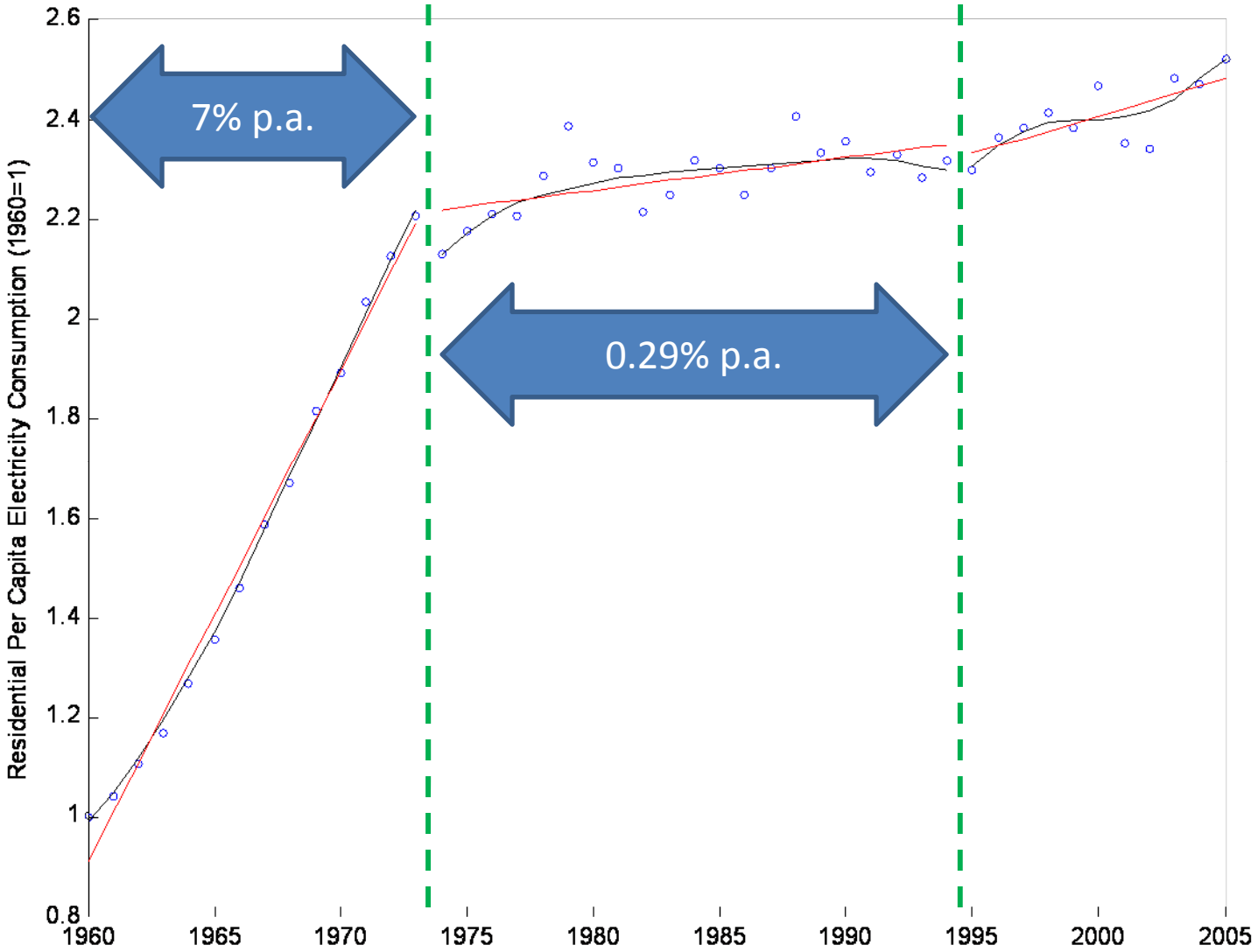
California Per Capita Electricity Consumption



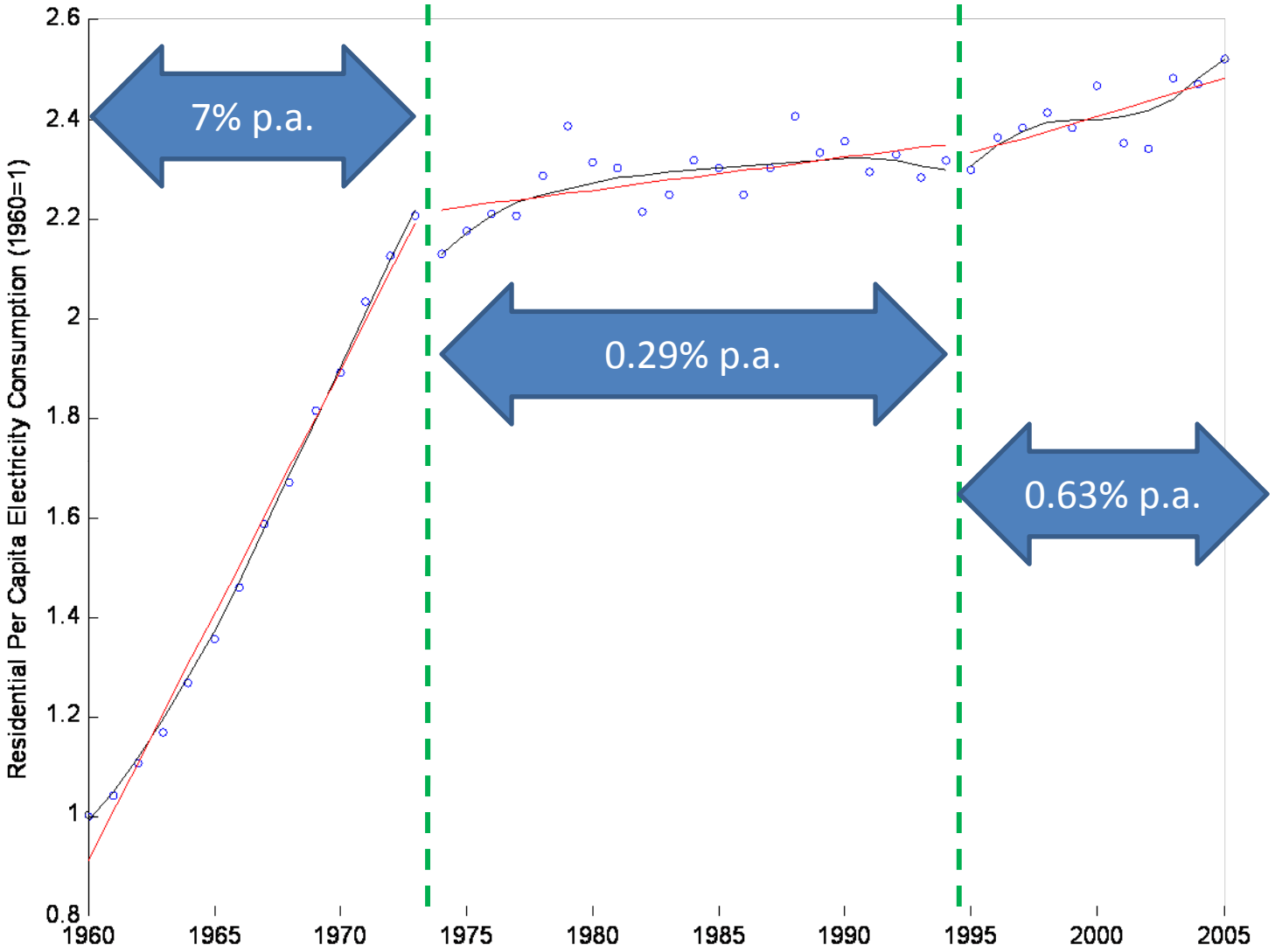
California Per Capita Electricity Consumption



California Per Capita Electricity Consumption



California Per Capita Electricity Consumption



Impacts of Climate Change on Electricity Consumption

- Bottom-Up Simulation Models
  - Baxter & Calandri (1992)
  - EPA (1989)

- Econometric Based Simulation Models
  - Mendelsohn (2003)
  - Franco and Sanstad (2008)
  - Deschênes and Greenstone (2007)

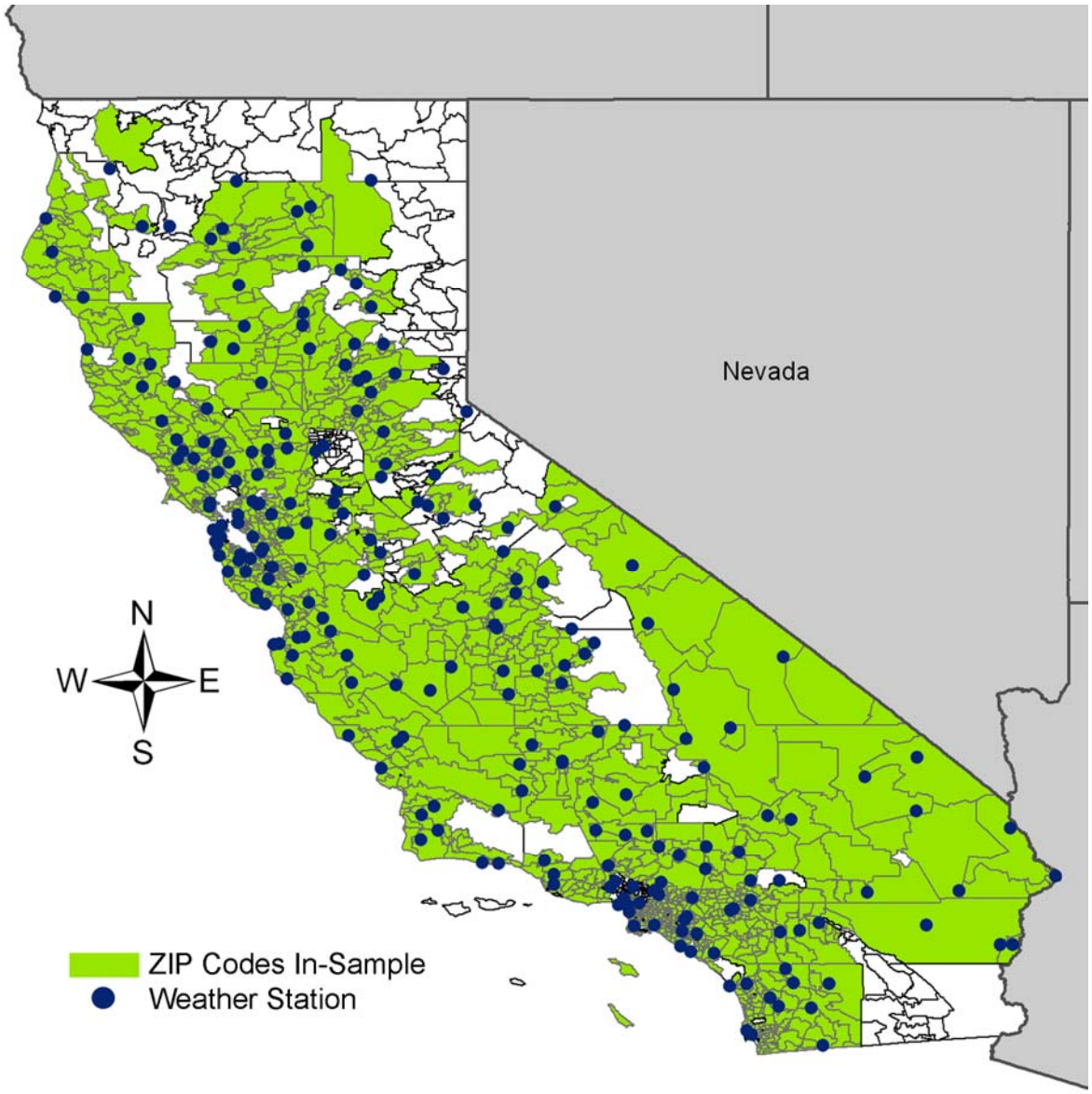
Our Approach

- Use random fluctuations in weather to identify temperature response of demand
- Use flexible functional form of temperature response.
- Allow for geographically differentiated temperature response
- Simulate future household and aggregate demand under different climate, price and population scenarios

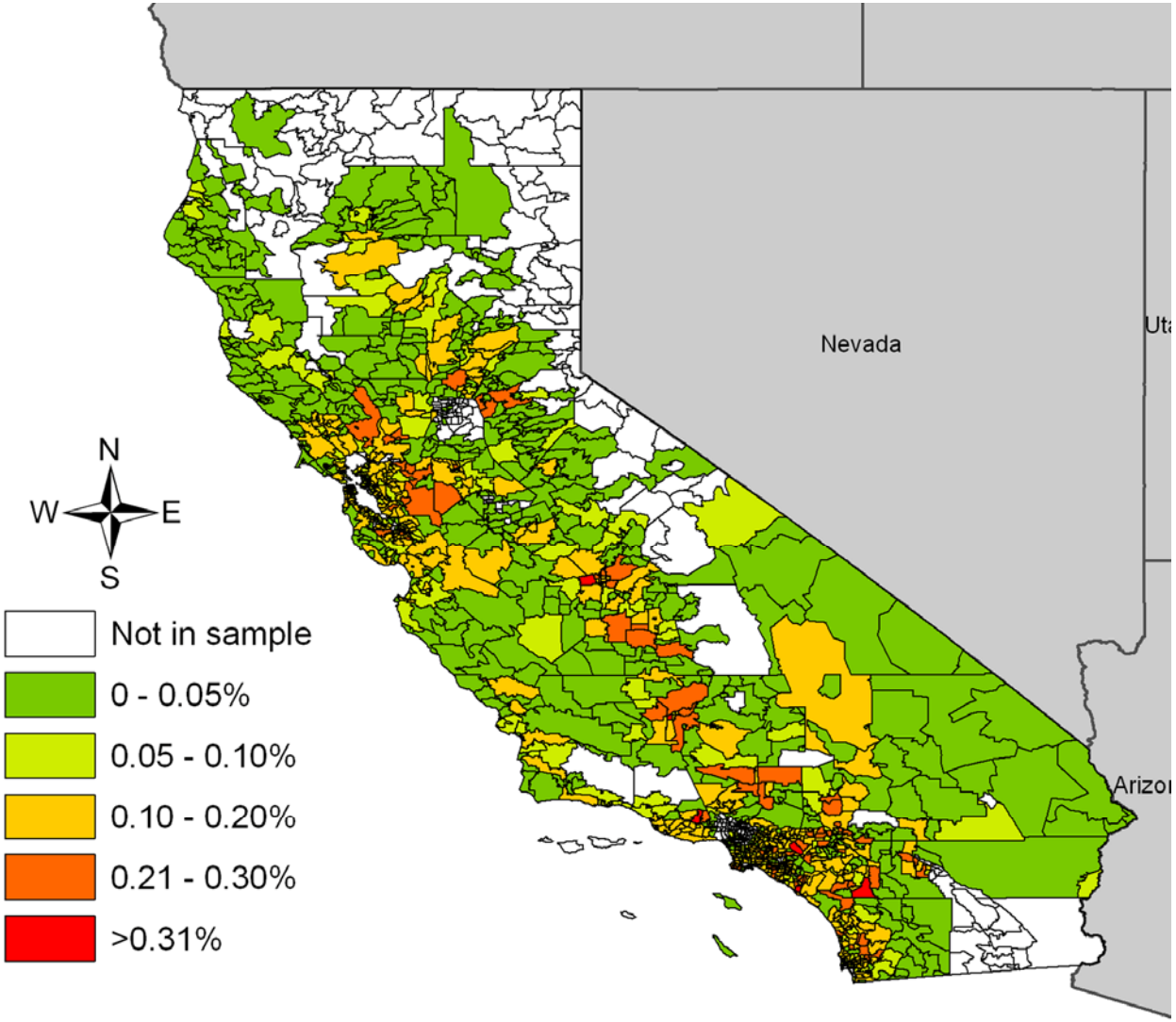
Data

- Access to complete billing data for California's investor owned utilities.
- Observe complete bills for ~80% of all California households from 2003-2006
- ~ 90 million bills
- Match to recorded temperature and rainfall at closest weather station and 5-digit zip.
- Drawback: Only know price, weather and 5-digit zip.

Data Coverage



Consumption Shares by ZIP



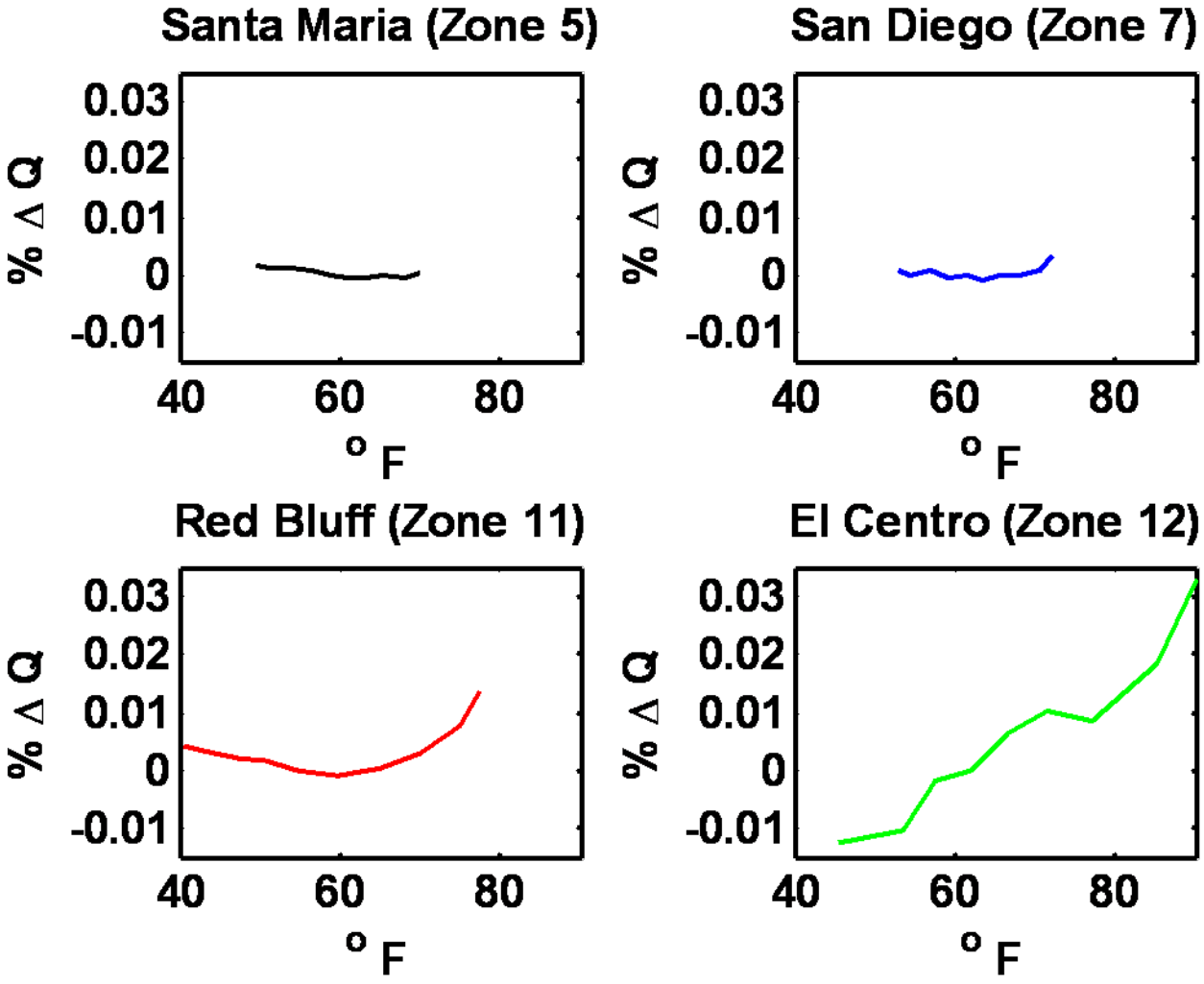
California Building Climate Zones

Econometric Estimation

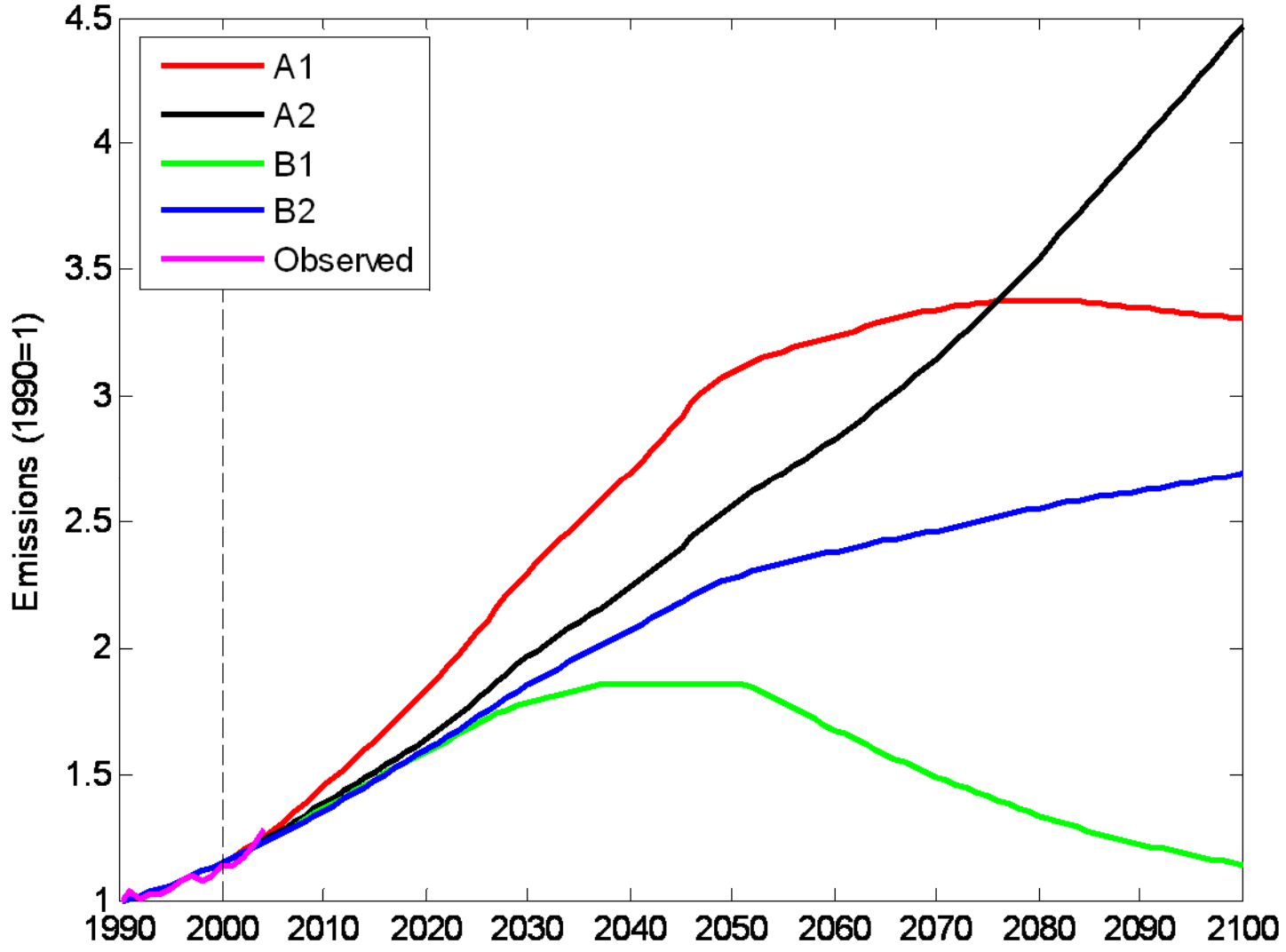
$$\ln(q_{it}) = \sum_{p=1}^{10} \beta_p D_{pit} + \gamma Z_{it} + \alpha_i + \phi_m + \varphi_y + \varepsilon_{it}$$

- Explicitly control for average prices and rainfall (Z_{it})
- Control for unobservables at the household level (α_i)
- Control for shocks common to all households by month and year (φ_y, ϕ_m).
- Flexible functional form for temperature using decile bins by climate zone.

Estimated Temperature Response Functions



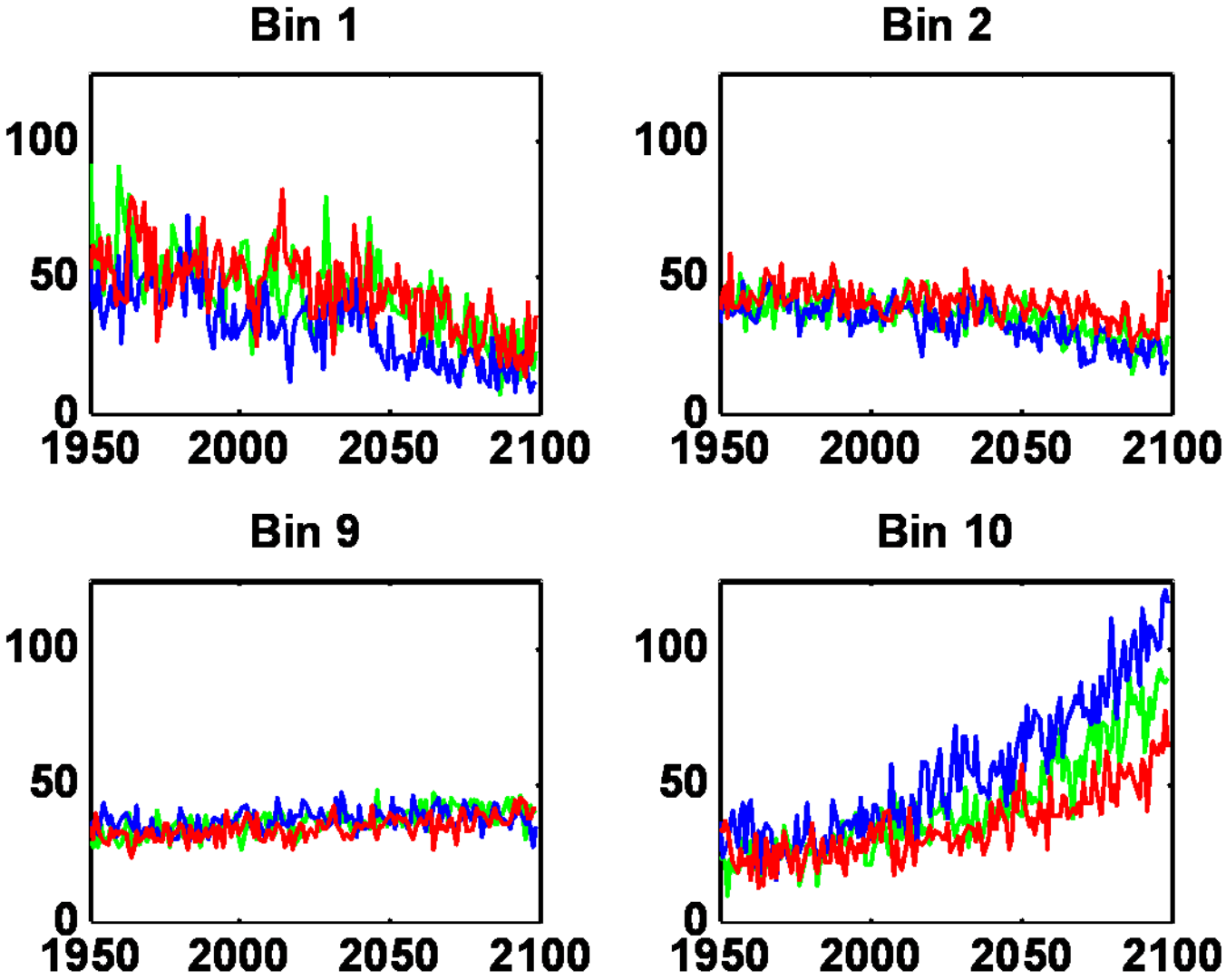
The IPCC long term trajectories



Source: IPCC SRES (2000) – Fossil Fuel Related Carbon Emissions World

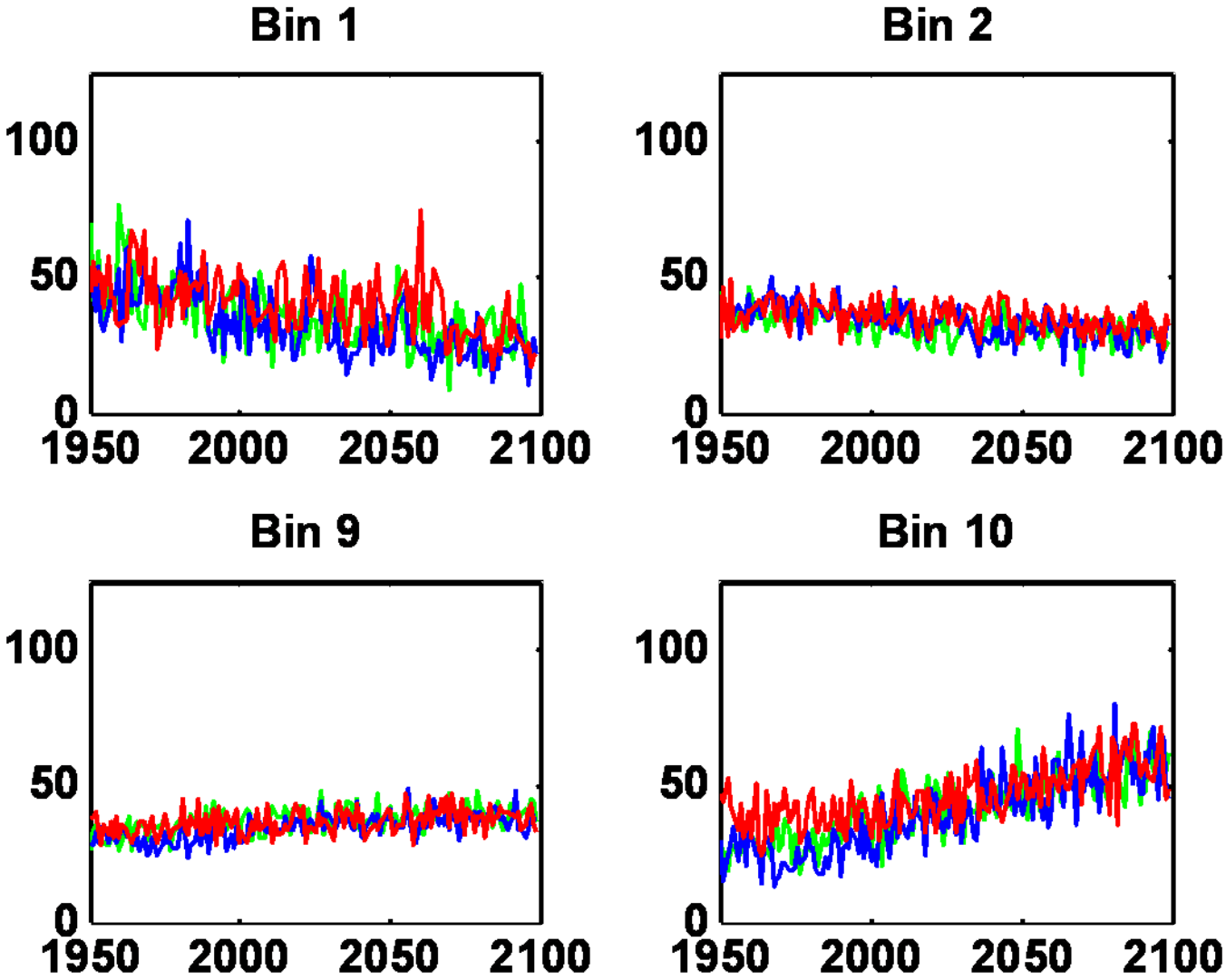
Central Valley Decile Days (A2)

(Blue = GFDL; Green=CRMC; Red=NCAR)

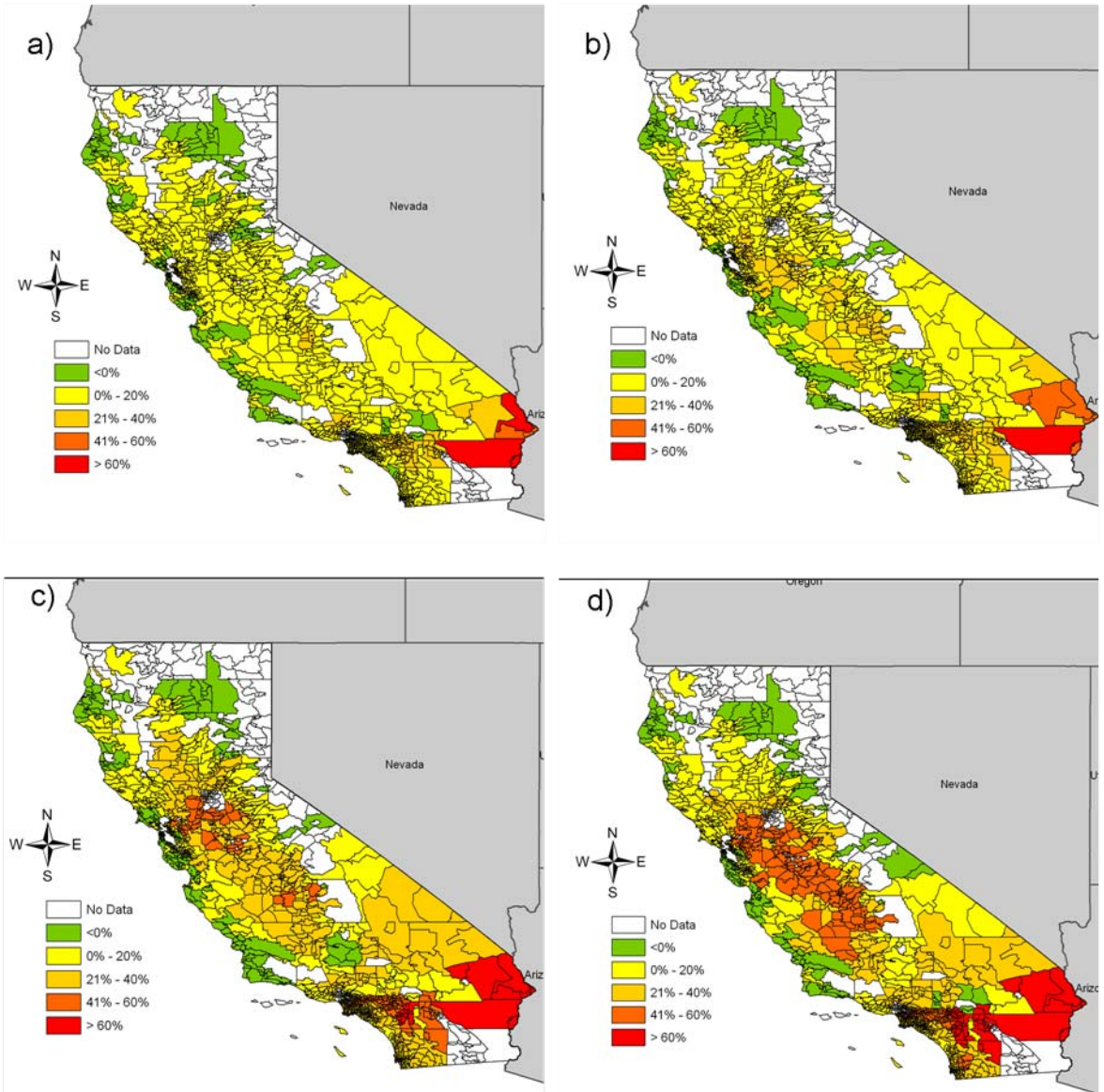


Central Valley Decile Days (B1)

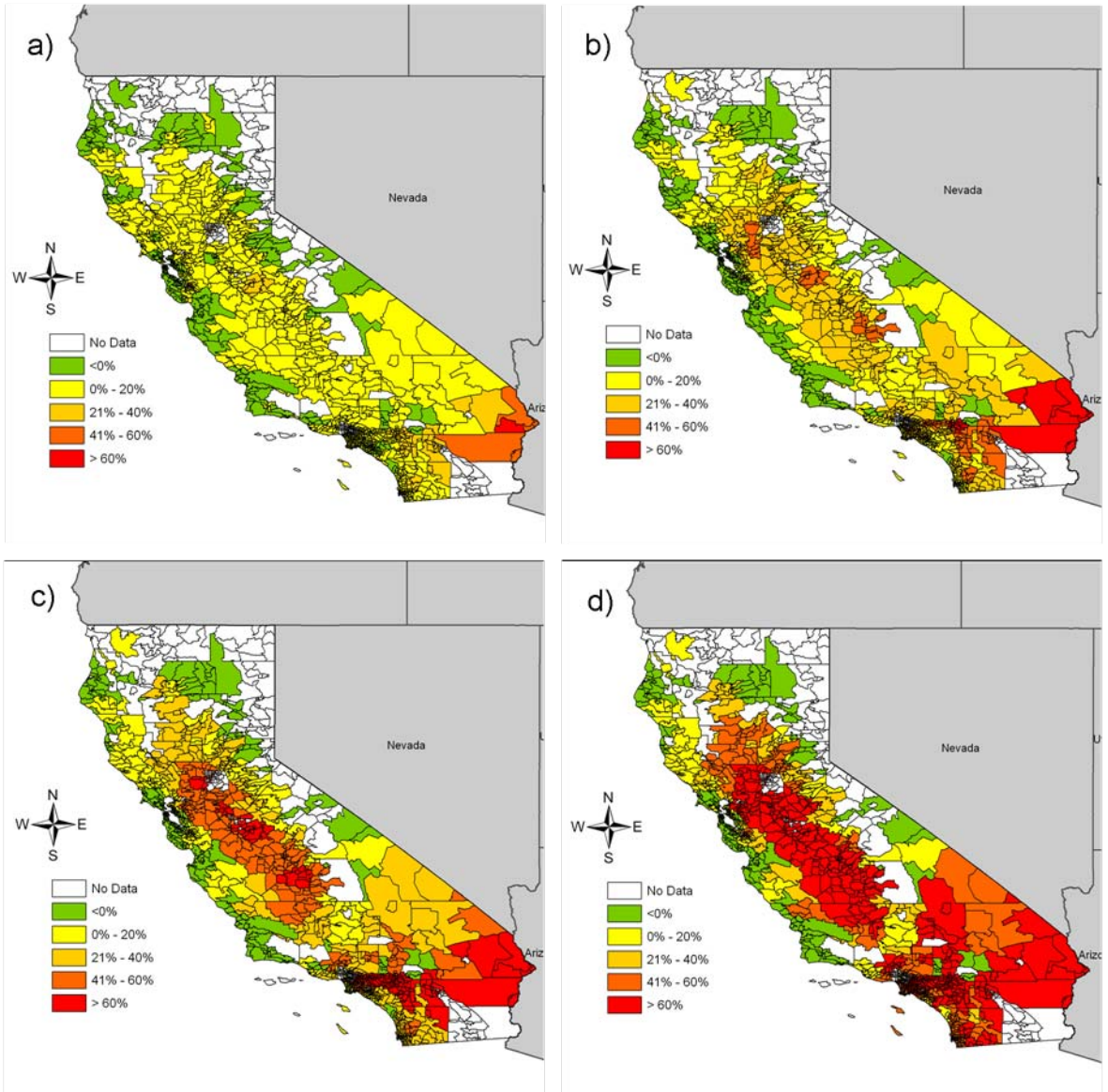
(Blue = GFDL; Green=CRMC; Red=NCAR)



Household Level Impacts (NCAR, B1)



Household Level Impacts (NCAR, A2)



Aggregate Demand Simulation (Price)

- Scenarios:
  - Constant Price
  - 30% persistent increase in 2020
  - 30% increase in 2020; 30% increase in 2040

Model	NCAR	NCAR	NCAR	NCAR	NCAR	NCAR
Forcing	A2	B1	A2	B1	A2	B1
Prices	Constant	Constant	30%	30%	30%/30%	30%/30%
2000-19	7%	3%	7%	3%	7%	3%
2020-39	8%	10%	-3%	-1%	-3%	-1%
2040-59	21%	14%	8%	2%	-4%	-9%
2060-79	33%	24%	19%	11%	5%	-2%
2080-99	61%	29%	45%	16%	28%	3%

Aggregate Demand Simulation (Population)

- Scenarios:
  - Low: 1.47% Growth p.a.
  - Middle: 0.88% Growth p.a.
  - High: 0.18% Growth p.a

Model	NCAR	NCAR	NCAR	NCAR	NCAR	NCAR
Forcing	A2	B1	A2	B1	A2	B1
Population	Low	Low	Middle	Middle	High	High
2000-19	20%	15%	22%	17%	26%	21%
2020-39	38%	41%	58%	61%	73%	76%
2040-59	65%	54%	121%	106%	158%	141%
2060-79	92%	75%	191%	168%	287%	256%
2080-99	156%	98%	321%	230%	568%	423%

Adaptation Demand Simulation

- Scenarios:
  - By Zone: Zone specific temperature response
  - Zone 7: Entire state like San Diego
  - Zone 13: Entire state like Central Valley

Model	NCAR	NCAR	NCAR	NCAR	NCAR	NCAR
Forcing	A2	B1	A2	B1	A2	B1
Response	By Zone	By Zone	Zone 7	Zone 7	Zone 12	Zone 12
2000-19	7%	3%	3%	1%	13%	7%
2020-39	8%	10%	2%	3%	17%	20%
2040-59	21%	14%	5%	4%	44%	28%
2060-79	33%	24%	8%	7%	74%	49%
2080-99	61%	29%	14%	8%	141%	64%

Summary

- California's residential electricity demand temperature response heterogeneous across climate zones.
- Study suggests larger increases in residential electricity demand than previous studies.
- Population uncertainty has a larger effect on overall demand than climate uncertainty
- Technology and price simulations suggest significant role for policy.